

Current Trends in Evolving Specialization in UK Universities

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Abstract

There are very significant changes taking place in the university sector and in related higher education institutes in many parts of the world. In this work we look at financial data from 2010 and 2011 from the UK higher education sector. Situating ourselves to begin with in the context of teaching versus research in universities, we look at the data in order to explore the new divergence between the broad agendas of teaching and research in universities. The innovation agenda has become at least equal to the research and teaching objectives of universities. From the financial data, published in the Times Higher Education weekly newspaper, we explore the interesting contrast, and very opposite orientations, in specialization of universities in the UK. We find a polarity in specialism that goes considerably beyond the usual one of research-led elite versus more teaching-oriented new universities. Instead we point to the role of medical/bioscience research income in the former, and economic and business sectoral niche player roles in the latter.

Keywords: research funding, student recruitment, budget, costs, higher education, university, finance, economics, United Kingdom, correspondence analysis, multivariate data analysis.

1 Introduction

Jenkins (2004) cites Barnett (2003, p. 157): “the twentieth century saw the university change from a site in which teaching and research stood in a reasonably comfortable relationship with each other to one in which they became mutually antagonistic”. In his Conclusions, Jenkins (2004, p. 31) states: “From the UK and the USA there is clear evidence that national policies and funding for research has resulted in structural separations between research and teaching within the institution.”

The traditional view of the university encompassing teaching and research is changing. Jenkins (2004, p. 5) had earlier noted the following: "... we may have to move away from seeing or disputing a single teaching-research nexus, and develop our understanding of the diverse and heterogeneous ways in which teaching and research are linked or not." Also (p. 31): "It is possible for institutions with different resources and missions to shape and deliver a view of the teaching-research nexus that reflects the resources available."

Jenkins (2005, p. 9), in discussing "teaching 'only' and research-intensive institutions" concludes (p. 50) that creation of 'teaching-only' universities is not justified; also that the aspiration should be that "all students in all higher education institutions learn in a research environment".

To begin with, therefore, we note this change whereby fairly complete harmony (assuming that was once the aspiration or perception) between the teaching and research agendas is no more. In this article, we aim to look at data in order to explore this new divergence between teaching and research in universities. An econometric model focused on the trade-off by universities of teaching and research is pursued by Beath et al. (2011). Our methodology in this work owes more to Benz  cri and perhaps Bourdieu too, in that we want to let the data reveal itself in the first instance, and then, following on from that, model the data. See e.g. Lebaron (2011).

In addition to the teaching and research agendas, it is our view that the business agenda has come to the fore in recent times, increasingly on a par with teaching and with research being ever more closely aligned with this business agenda.

The plan can be viewed in the following terms, with the emphasis in the original (BIS, 2010): "Research Councils and Funding Councils will be able to focus their contribution on *promoting impact through excellent research, supporting the growth agenda*. They will provide strong incentives and rewards for universities to improve further their relationships with business and deliver even more impact in relation to the economy and society."

Hence we have the new orientation in the university arena that has become prominent in recent years, and has been strongly propelled forward by the economic downturn following the great banking and (in some countries) real estate crash of 2008. The objective is ever increasingly becoming: "to foster more effective collaboration between universities and business in the years ahead" (McMillan et al., 2010, p. 3).

That the business innovation agenda has become central to the higher education sector is not in doubt. It is our implicit viewpoint in this work that innovation, understood as encompassing business, entrepreneurial and economic activities, has come to be on a par with research and teaching. However our article is not dependent on accepting this viewpoint, either entirely or in terms of the change being deep – although we ourselves take this view.

One motivation for the turn towards innovation in this sense is additional earning potential through "third stream" income. Hatakenaka (2005) considers this in the UK university context. Apart from such third stream income, there is also human capital being more aligned with business needs. Having innovation

on a par with teaching and research as a new characteristic of higher education is the main motivation for this article. Within this context, it seems clear that the institution of university is changing. Some examples of such influence include entrepreneurial course modules or other forms of business oriented activity on Masters, or undergraduate courses, and on structured graduate training that is part of PhD programmes. We can note also the debate around the future role of the PhD degree (see the journal *Nature*, volume 472, issue of 21 April 2011).

Reasoning further, if the economic crisis post-2008 is engendering change in the higher education system, as elsewhere, through government and other agencies being strapped for funds to dispense, for research, teaching and associated business growth, then what does empirical data have to reveal in regard to this?

This article is based on two revealing data sets that provide a snap shot of the financial health of UK universities. We looked at this data in order to see what sort of institutional approaches seem to be doing well, in the contemporary economical climate.

1.1 Data and Objectives

Brief background on the UK universities and funding system can be found at, for example, <http://www.internationalstaff.ac.uk/universities.in.the.uk.php>

The data on financial health and safety of UK universities and other similar third level or higher education institutes that were published in the Times Higher Education newspaper have their own tale to tell, as we will show in this article. We use in particular the reports of Newman (2010) and Baker (2011). In Newman (2010) it was noted how the downturn in Government spending led to university budgetary deficit in many cases, but this was coupled with strong student demand and with cost inflation being very much down. One year later, Baker (2011) pointed to overall university finances being “fairly healthy” but pointed to approaching turbulent times, affecting State funding of the sector, and also undergraduate, postgraduate and non-European (incurring higher registration fees) recruitment. Baker (2011) referred to the “oncoming tempest”, of a sustainability sort.

All aspects of the sector’s financials are relevant here, including salaries, pensions and pension commitments, as well as student recruitment. Research funding is important too, although there have been major changes in regard to this in recent years: “Even research income – protected by the government overall – is a problem for the majority owing to the increasing concentration of funding on a small band of institutions.”

Against this backdrop, and based on university financials, we ask what has been the higher education system’s response. To avoid indebtedness, what sort of role or profile is the university adopting?

Our methodology is based on “letting the data speak”, to begin with, followed by drilling down in the data, in pursuit of patterns or trends. In the case of a need to test hypotheses statistically, the most straightforward approach to take is then based on randomization tests. Our goal here though is to discern

clearcut patterns or trends, and to show the current state of play in regard to relative positioning of universities.

By studying such “relative positioning” we seek to inform and influence policy and decision making. In Murtagh (2010) resulting from the Sixth Annual Boole Lecture (organized by the Boole Centre for Research in Informatics, <http://www.bcri.ucc.ie>) in 2008, we show how information focusing is carried out in data analysis, i.e. determining where the data is put under the analytic microscope. One issue addressed is coverage and completeness of research funding in technological sector domains. Another issue addressed is evolution of funding decisions over time. We show how the narrative of science and engineering policy – the story that policy decisions have to tell – can be mapped out from the raw data. The orientation of such narrative is crucial.

In this present work, we use the same data analysis approach, Correspondence Analysis. Based on the data on UK HEI (higher education institute) financials provided by Newman (2010), we look for underlying patterns of particular interest. The data is due to accountancy firm Grant Thornton and is based on institutions’ financial statements for 2008-2009. In section 5 we look at data from 2009-2010.

In Murtagh (2010) we provide background on the analysis approach which takes cross-tabulations as inputs – in this case of HEIs crossed with financials on a set of incomes or expenditures. *Profiles* of the (positively-valued) data, on either rows (i.e., HEIs) or columns (i.e. financial incomes or expenditures) are mapped into the same visualizable (hence Euclidean distance-based) space. *Profiles* are values in the row or column that are divided by the row/column total. Hence HEIs, or financial attributes, are normalized in this way – by dividing by their respective row/column totals.

A range of analysis options are opened up by the Correspondence Analysis: simultaneous display of HEIs and incomes/expenditures; optimal planar display; accounting for most of the information content (in a precise mathematical sense) of the data; among others.

2 Attributes and Interpretation of the Planar Visualization

Attributes used in the main analysis were as follows. These attributes constituted the primary data used on the 155 institutions.

- Attribute 3, Funding council grants (all grants of: HEFCE, Higher Education Funding Council for England; or HEFCW, Higher Education Funding Council for Wales; or SFC, Scottish Funding Council).
- Attribute 4, Research grants and contracts (from all sources other than HEFCE/HEFCW/SFC).
- Attribute 5, Tuition fees and education contracts (excluding overseas, i.e. non-European resident). (UK and European including short courses or

other ancillary teaching).

- Attribute 6, Overseas fees.
- Attribute 7, Other income (from catering, residential, possibly from companies spun out).
- Attribute 8, Endowment and investment income.
- Attribute 11, Total staff costs (including social security and pension contributions).
- Attribute 13, Total borrowing.

We omitted net surplus (attribute 1) because of the remarks in the Times Higher, noting how Cambridge had the largest deficit but it was a very small percentage of its total income; Bucks New University recorded a large deficit but then sold a campus to reverse this deficit; and Thames Valley University had a surplus but this disappeared when HEFCE was reimbursed for this university's over-reporting of its fundable student numbers. Our interest lies in financial health. Arising from this, we were interested not in the financial position as such but rather in determining underlying indications of where the sector is headed as it seeks to address the current economic climate. So we used the more basic financial data.

Attributes projected into the analysis subsequently were as follows. These were attributes derived from the more basic data.

- Attribute 2, Net surplus as % of income.
- Attribute 10, Funding council grants as % of income.
- Attribute 12, Total staff costs as % of income.
- Attribute 14, Total borrowings as % of income.

Fig. 1 summarizes the data. Shown in the figure is a principal plane projection, accounting for $42 + 30 = 72$ % of the information content – most, therefore.

Factor 1 is dominated in influence by attribute 4, “Research grants and contracts”. Such domination is determined not just by its relatively extreme (positive or negative) projection on this first (newly determined) coordinate axis, but also by its *contribution* to, and its *correlation* with, the first axis. (Contribution, correlation, inertia expressing information, factor, and so on are all mathematically defined terms in the Correspondence Analysis data analysis and display context.)

For Factor 2, the dominant attribute is 13, “Total borrowing”, and attribute 11, “Staff costs”, is not far behind in terms of influence.

On Factor 2, it can be seen that attribute 14, “Total borrowing as % of income”, is in the same general region as 13, “Total borrowing”. We can note

Times Higher 2008-2009 financial data. 155 institutes at dots.

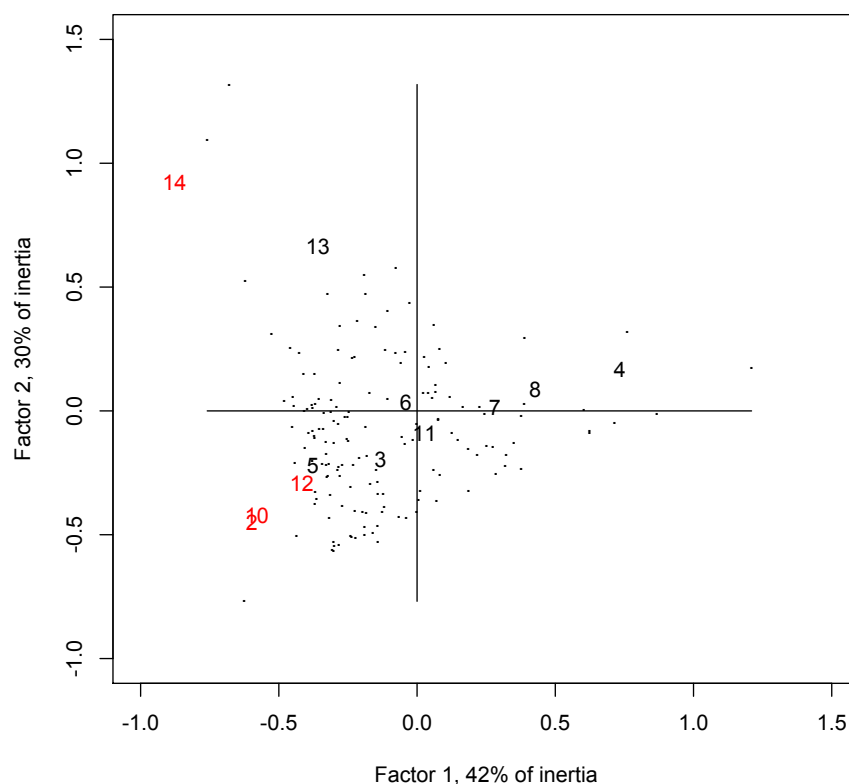


Figure 1: A first visualization of the data: the main analysis is based on the data table for 155 UK higher education institutions using the Times Higher attributes (see text for these) 3, 4, 5, 6, 7, 8, 11, and 13. Their locations can be seen in the (numeric values in the) planar projection. In addition, based on the analysis of the main data, the locations were found for the more “illustrative” attributes, 2, 10, 12, and 14. These latter are shown in red. The higher education institutes, in order not to crowd this initial display, are each shown as a dot.

too that, counterposed to 13 and 14, there are attributes 2 (surplus-related), 10 (funding council grants-related), 12 (staff costs-related), and also 5 (tuition fees) and 3 (funding council grants) – all possible countervailing means relative to borrowing.

Interestingly, attributes 2 and 10 – “Net surplus as % of income”; and “Funding council grants as % of total income” – are closely located, indicating that the information conveyed is very similar. Attribute 6, “Overseas fees”, is close to the origin of the display, indicating where it is a not very discriminating attribute here.

Fig. 2 is the same as Fig. 1, just showing the areas where we will now mostly focus our attention.

3 Factor 1: Role of Medical Disciplines in HEIs that are Strong in Research Funding

The most positively linked institutes relative to Factor 1 are to be seen in Fig. 3. These are:

- Cambridge (“Cam”, overlapping “SAGC”)
- Institute of Cancer Research (“ICan”)
- Liverpool Sch Tropical Medicine (“LTSM”)
- Tropical Medicine – London Sch Hygiene & (“LSHTM”)
- Oxford (“Oxon”)
- Scottish Agricultural College (“SAGC”, overlaid on “Cam”)
- University of Wales (an administration only institute) (“UoW”)

Somewhat less pronounced in terms of this factor are: Imperial, UCL (University College London) and University of Edinburgh.

Apart from the traditionally strong Oxbridge research presence, what is also noteworthy is the medical and biosciences presence, albeit specialist, in this cluster.

Adams and Gurney (2010) point to how citation ratings from Thomson Reuters attribute the lion’s share of UK research outcomes to five HEIs: Oxford, Cambridge, Imperial, UCL, and LSE (London School of Economics). In our concluding section below we will return to this view of performance and achievement evaluation.

4 Factor 2: Borrowing

As noted Factor 2 is firstly and foremostly related to borrowing. Fig. 4 shows the positive end of this factor. We see a number of institutions that are flagged

Times Higher 2008-2009 financial data. 155 institutes at dots.

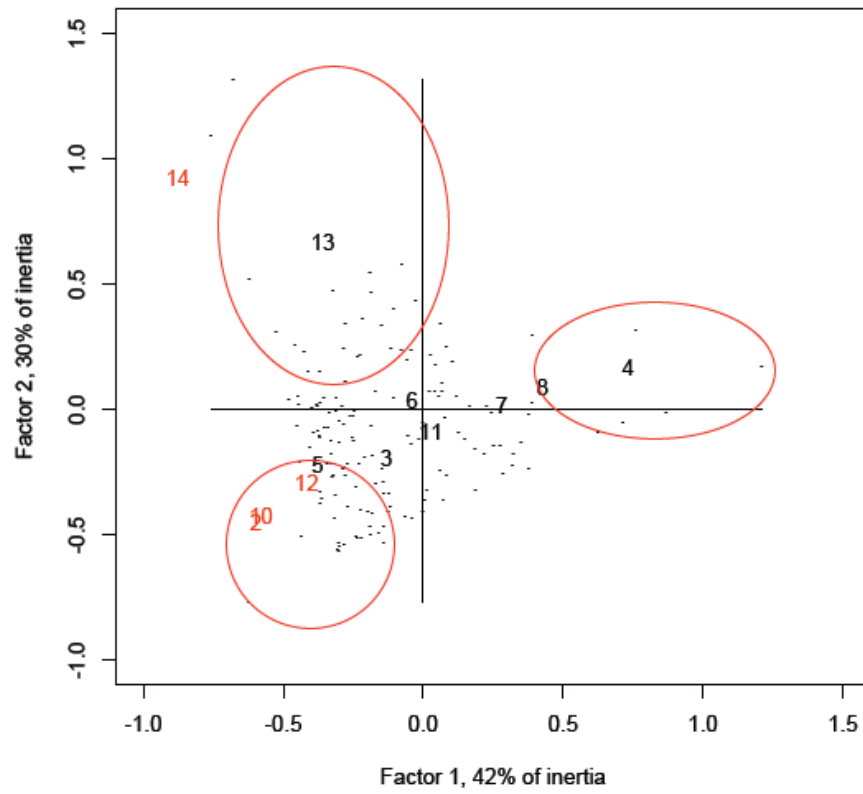


Figure 2: We will focus attention on the rightmost HEIs here; on the upper left ones; and finally on the lower rightmost. Meanwhile both HEIs and attributes that are close to the origin (coordinate 0, 0) are average, relating either to average HEI profile, or to average attribute profile.

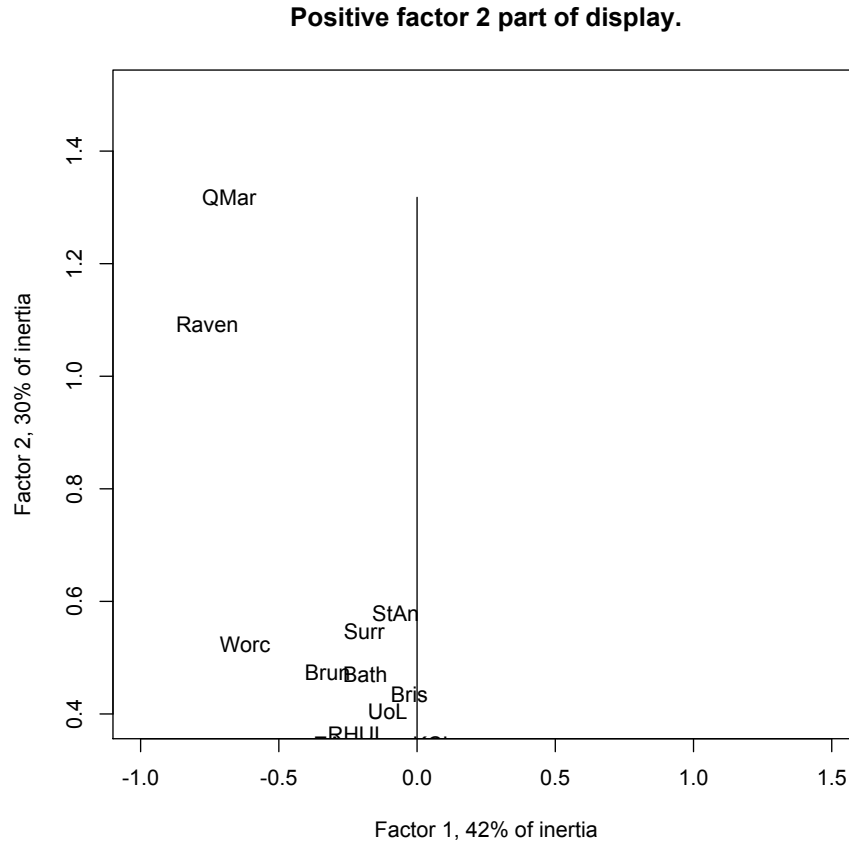


Figure 4: The higher education institutes: the positive end of Factor 2, cf. the complete view in Fig. 1.

in the Times Higher article in terms of high gearing, i.e. “Total borrowings as & of income”: Queen Margaret University, 220.5% of income; Ravensbourne College, 171%; University of Worcester, 82.5%; University of Surrey, 63%; and Brunel University and the University of St Andrews, both 62%.

We will next look at the non-gear end of Factor 2. We look at what is most opposite the research, Oxbridge, medical and biosciences, end of Factor 1. What we find in Fig. 5 is that the following institutes are to be found there:

- Conservatoire Dance & Drama (“CDD”)
- Bishop Grosseteste (“BiGr”)
- Bath Spa (“BSpa”)

- Swansea Metropolitan (“SwanM”)
- Newman College (“Newm”)
- Liverpool Inst Performing Arts (“LPerf”)
- UHI Millennium Institute (“UHIMI”)
- Leeds Trinity (“LTrin”)
- Manchester Metropolitan (“ManM”)
- Open University (“OU”)
- London Business School (“LBS”)
- West of Scotland (“WoS”)
- Glasgow Caledonian (“GCal”)

We note specialist and/or business – or business sector – orientations that are well represented among these institutions. Note again that these institutions are not at all as highly geared as those institutions that are more towards the positive end of Factor 2.

5 From 2008-2009 to 2009-2010

In Baker (2011), data is presented for 2011. Some (small number of) universities differ in the list of 154 used in 2009-2010, compared to the list of 155 used in 2008-2009. It is seen though that the overall characteristics of the data are very similar: cf. Figs. 1 and 6.

In regard to the rightmost projections on Factor 1 of Fig. 6, we again find the following (in order of prominence, given by projections). (Fig. 4 had zoomed in on this part of display for the 2008-2009 data.)

- Liverpool Sch Tropical Medicine
- Institute of Cancer Research,
- Scottish Agricultural College
- London Sch Hygiene & Tropical Medicine
- Oxford
- Cambridge
- University of Wales
- University College London

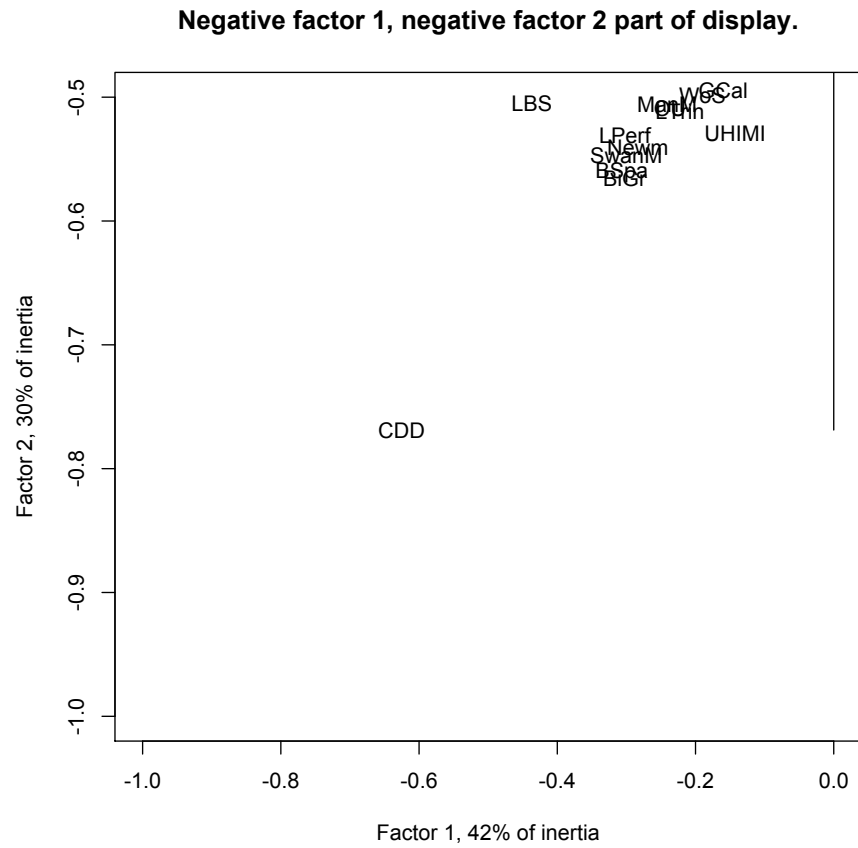


Figure 5: The higher education institutes: the negative ends of Factor 2 and of Factor 1, cf. the complete view in Fig. 1. These are less research funding-based, and also non-borrowings geared, institutions.

Times Higher 2009-2010 financial data. 154 institutes at dots.

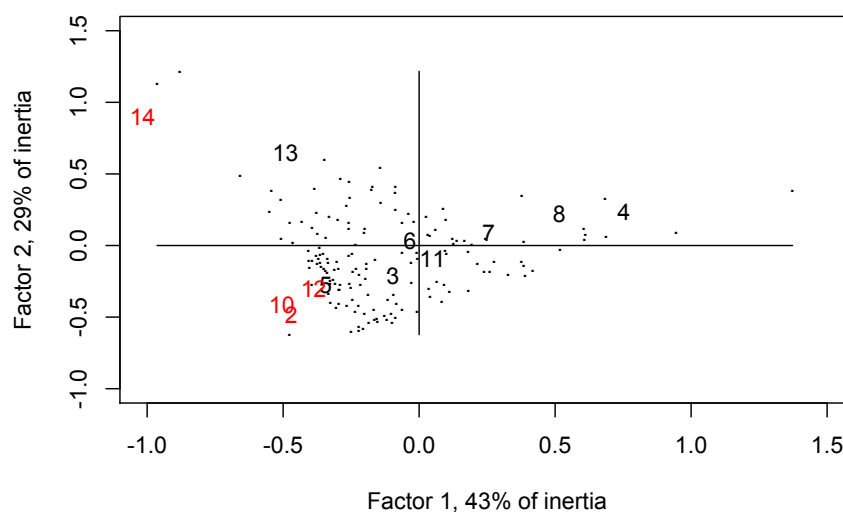


Figure 6: Fig. 1 was related to 2008-2009 and, here, we have 2009-2010 data. This is a visualization of the data: the main analysis is based on the data table for 154 UK higher education institutions using the Times Higher attributes (see text, section 2, for these) 3, 4, 5, 6, 7, 8, 11, and 13. Their locations can be seen in the (numeric labels in the) planar projection. In addition, based on the analysis of the main data, the locations were found for the more “illustrative” attributes, 2, 10, 12, and 14 (see also section 2). These latter are shown in red. The higher education institutes, in order not to crowd this initial display, are each shown as a dot.

With reference again to the 2009-2010 data, we find the most prominent on Factor 2 (cf. for 2008-2009, Fig. 5) to be:

- Queen Margaret
- Ravensbourne

These are then followed by: Surrey, St Andrews, Worcester, Reading, Bath, University of London, Bristol.

In regard, for 2009-2010, to the lower left quadrant of Fig. 6, and with reference to the year earlier of 2008-2009 shown in Fig. 7, on this occasion – 2009-2010 – we do not have data for the Conservatoire for Dance and Drama (labeled “CDD” in Fig. 5).

We do find others though, in order of prominence by projection on Factor 1:

- London Business School
- Bath Spa
- Newman University College
- Swansea Metropolitan
- Bishop Grosseteste
- Manchester Metropolitan
- Liverpool Inst Performing Arts

Overall we see that there is little relative difference between the two sets of data, for 2008-2009 and 2009-2010.

6 Implications and Conclusions from the Correspondence Analysis

We conclude that:

- Factor 1 is primarily based on research funding, not from HEFCE and sister organizations outside England but rather from research councils, and also is indicative of the particular importance of medical and bio-science research funding which results in institutes that we have noted being strongly positioned on this underlying dimension in the data. As a part of this finding, we note this central role played by medical and closely related disciplines.
- Factor 2 is primarily borrowing, with the property of gearing (i.e., borrowing relative to income) being particularly useful to explain this. Newer institutes, with limited but focused course offerings, and with specialist

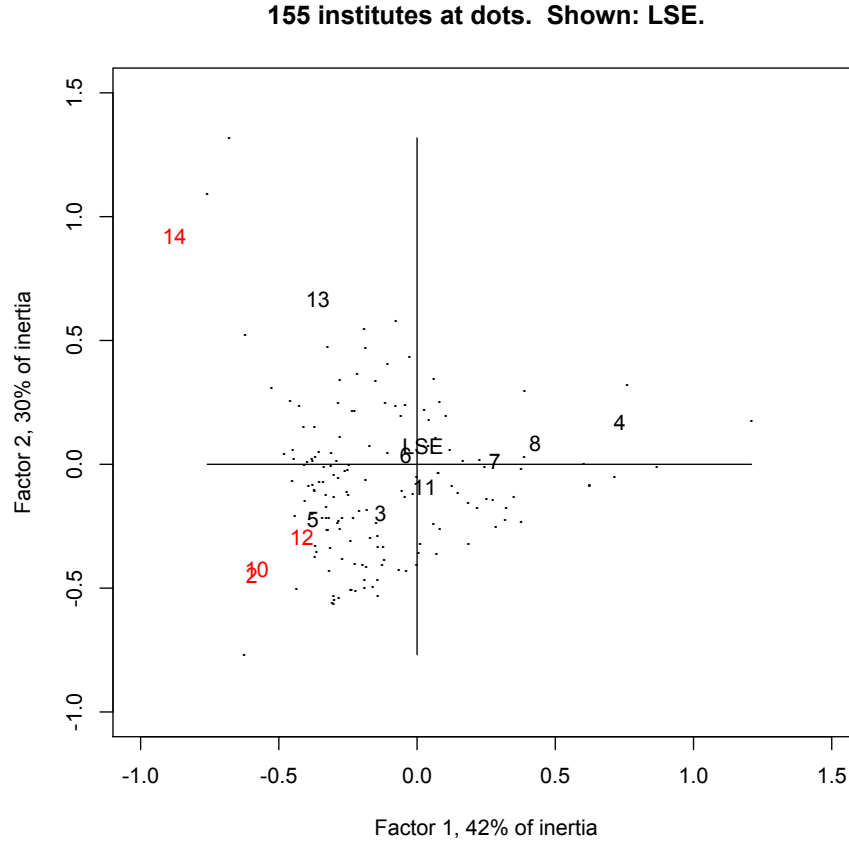


Figure 7: Again Fig. 1, with LSE (London School of Economics) displayed.

business or industrial sector orientations, together with the London Business School, the Open University, and the UHI Millennium Institute – latter now the University of the Highlands and Islands – are all the most extreme in the low (or zero) borrowing sense. In section 4 we have noted the highly geared institutions.

- Our main finding therefore is the polarity between, on the one hand, traditional research, by now well swayed towards medical and closely related research; and, on the other hand, newer and more specialist, or business-oriented institutions.

To draw out implications of this polarity we can show – see Fig. 7 – the placements of any of the HEIs. Properties vis-à-vis the Factor 1 and Factor 2 oppositions can be appreciated. For example, LSE is seen to be in an average

position.

7 Further Analyses of Correspondence Analysis Factors

From the 2009-2010 data, factors 3 and 4 (F3, F4) have this tale to tell.

- Attribute 6 at the negative end of F4 relates to Overseas fees.
Attributes 10, 14, then followed by attributes 2, 12 at the positive end of F4. These are all supplementary attributes, i.e. projected into the analysis passively. Attributes 2, 12 relate to Net surplus as
- Attribute 4 somewhat towards the positive end of F3. This attribute is Research grants and contracts other than HEFCE.
Attribute 7 at negative end of F3: Other income, – catering, residential, possibly companies.
F3 therefore distinguishes the sources of income.

In summary, F3 is attribute 4 versus attribute 7; F4 is attribute 6 versus all other attributes. F4 deals with the important, financially sustaining role, of non-European student fee income. F3, as noted, deals with other main sources of income.

We looked at some further factors and, while interesting for furthering the study of particular issues, we will not further pursue this here.

8 Model-Based Maximum Likelihood Cluster-Analysis to Specify Clusters of Universities

In Figure 8 we use the Correspondence Analysis, and hence Euclidean equi-weighted, data as input to the clustering. Furthermore we use the full dimensionality so there is no loss of information.

The clear three-cluster partition is displayed in the principal factor plane in Figure 9. As a planar display of the data, this display very much supports our previous discussion above which was in terms of interpretation of the factors.

In order to further support this cluster analysis outcome we sought corroborating evidence from a Gaussian mixture modeling of this data. (We used this approach of hierarchical clustering for initial analysis, followed by a model-based approach, in Mukherjee et al., 1998).

The modeling is carried out as follows. See Fraley and Raftery (1998, 2009). Take the covariance matrices, Σ_k , for cluster k . The eigendecomposition gives the decomposition: $\Sigma_k = \lambda_k D_k A_k D_k^t$.

We use the model that is termed EII, and explained as follows:

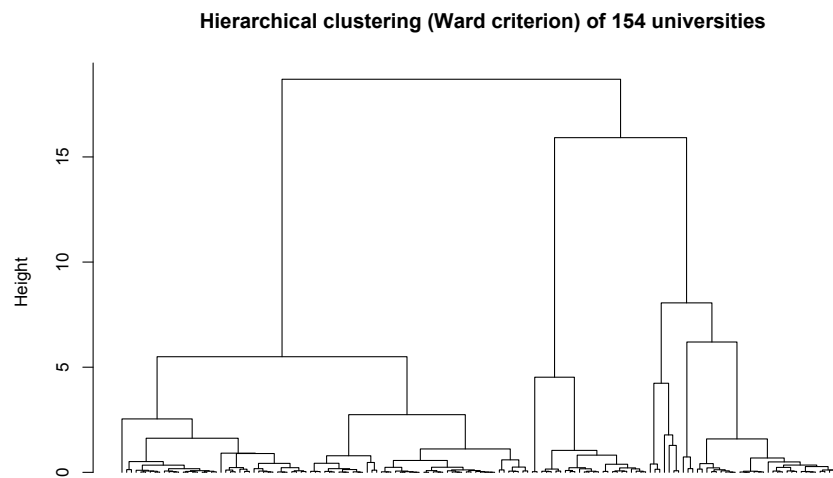


Figure 8: Hierarchical clustering, using Ward's minimum variance agglomerative criterion, using the full dimensionality, Euclidean and equi-weighted set of 154 universities, as given by the Correspondence Analysis. 2009-2010 data used.

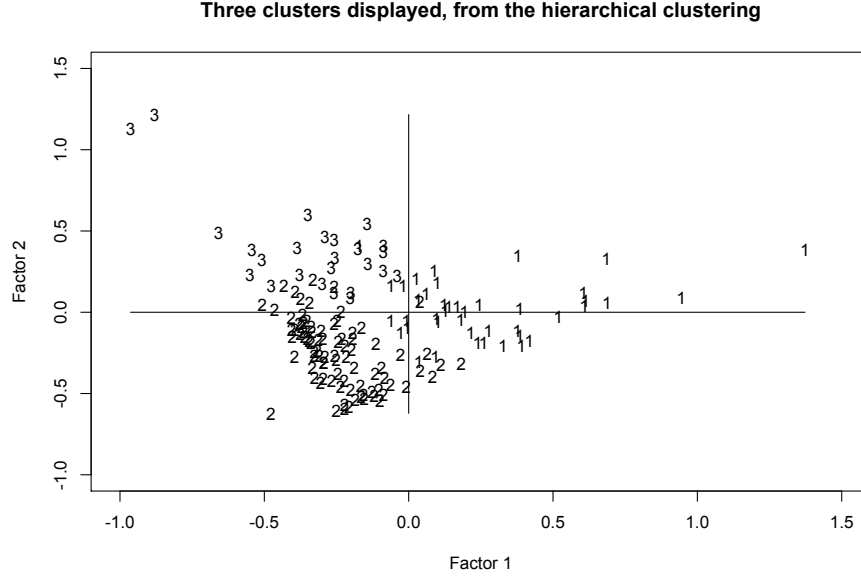


Figure 9: Display of the partition with three clusters, derived from Figure 8. The university locations are labeled 1, 2, and 3, relative to the three clusters.

- Equal volumes for the clusters.
- Equal shapes.
- Orientation of clusters is not relevant due to sphericity.

The model in this case is $\Sigma_k = \lambda I$ where I is the identity matrix, and λ is the same eigenvalue for all clusters k . Informally we are fitting hyperspherical balls of the same characteristics to our data. In this way, we determine the cluster components that, when aggregated, give rise to the complicated cluster morphologies that are observed in practice.

The Bayesian information criterion, BIC, is used for model identification. Figure 10 shows the outcome.

In Figure 11, we see the clusters projected in a principal coordinate plane. The principal coordinates were determined from the Euclidean Correspondence Analysis factor output, so the same outcome as we have in earlier figures is to be expected. The support that is found using this approach, relative to e.g. Figure 9, is strong. In fact we see how very well these clusters in Figure 11 related to the displays of Figures 3 (right hand side), 4 (upper left hand side) and 5 (lower left hand side).

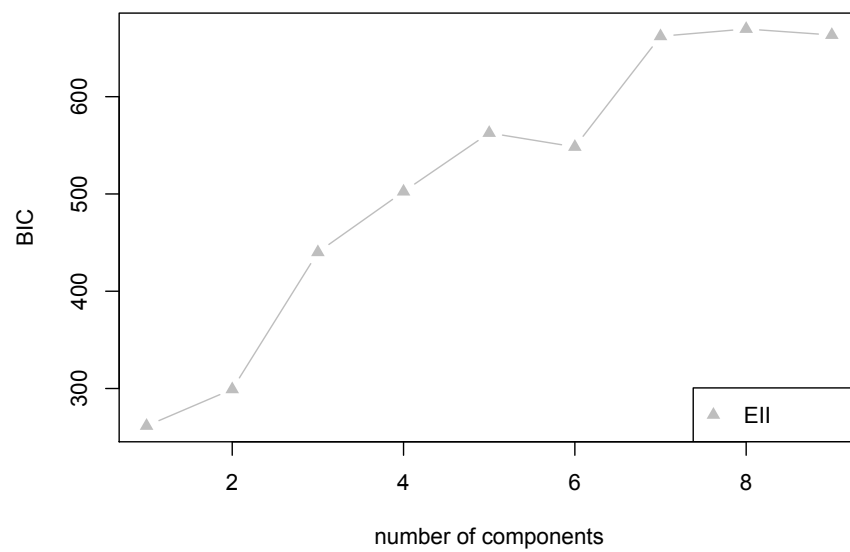


Figure 10: Bayesian information criterion, BIC, pointing to a best fit of 8 clusters for this EII (see text for details) model.

1,2 Coordinate Projection showing Classification

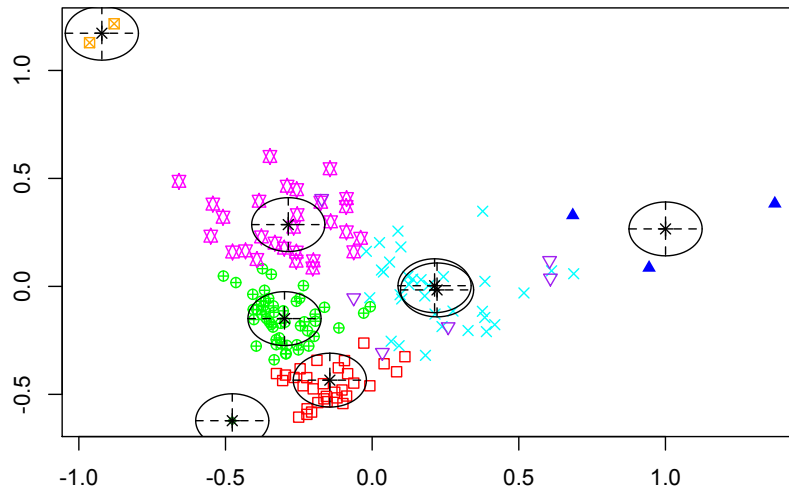


Figure 11: A principal coordinate projection of the 8 clusters found through fitting of the EII cluster model to the data. The clusters here are “components” of the complex morphologies that are found in practice.

9 Discussion and Conclusions

In studying world leadership in research, Adams and Gurney (2010) find five institutes (Oxford, Cambridge, UCL, Imperial, and LSE) to be significantly separate from all others, including others in the Russell Group of universities. Adams and Gurney label the five universities the “Golden Triangle”. The criterion used by Adams and Gurney is citation impact, based on Thomson Reuters databases. Of course this is not necessarily a good basis for the measurement of impact in, for example, computer science (see e.g. Moed and Visser, 2007) due to more limited coverage of the literature in this area and also different citation practices and culture (involving books and conferences, for example), and other disciplines can be added, in engineering, mathematics and the humanities.

When viewing the university system in its entirety, other forms of impact are clearly important also. These include human capital, sectoral and niche applications, and also engineering (as opposed to science) demonstrators and testbeds, and their deployment.

It is seen from our data analysis that the UK system is gravitating – in fact, it has largely already done so – towards two attractors: high research income, and what we have characterized as niche industrial/business sector application-oriented research, that also incorporates business and management, and human capital too. These corresponding to the right hand side of our displays, and to the lower left hand side, respectively.

Note that all of these planar projection displays are not invariant from the interpretation point of view, relative to a reflection symmetry about the axes. However for a given software implementation they are of course replicable.

Let us take one step further our findings in regard to these university “attractors”. We raise the question of what are appropriate performance metrics. On the one hand, impact of funded research, as measured through citations, which as a performance measurement tool is very fit for purpose across a wide range of disciplines including the life sciences, biosciences, materials science and others. On the other hand, performance that is evaluated by a narrative of impact is what is coming about in regard to outputs and outcomes from what we have characterized as niche industrial/business sector application-oriented research, that also incorporates business and management, and human capital.

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